

A Variable Potential Porous Silicon Carbide Hydrocarbon Gas Sensor

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A sensor which is capable of detecting hydrocarbons and distinguishing among them at temperatures in the range 100 - 500°C has been constructed from (111)-silicon carbide and tested in methane and propene. Experimental data show that it is possible to detect the presence of the two hydrocarbon gases and to distinguish between them. The ability to detect hydrocarbons and discriminate among them has applications in monitoring automobile emissions as well as monitoring functions in various process industries.

Semiconductor based sensors such as those made from SnO_2 are well known, and are capable of detecting oxygen containing compounds such as CO and CO_2 as well as hydrogen containing compounds such as NH_3 and H_2 [1]. In addition, such sensors are able to detect hydrocarbon compounds, but are not able to distinguish among them. Recent developments in silicon carbide material growth technology make it possible to construct sensors using SiC as the electronic material as well as the active material in a gas sensor. The importance of SiC is based upon its ruggedness and durability, as well as its potential for use at high temperature (much greater than 300°C) and power levels. In addition, SiC has excellent electrical and thermal characteristics.

A capacitor-type sensor based on a catalytic surface attached to a SiC substrate has been constructed and tested by Arbab et al. [2]; that sensor requires high temperatures (> 500°C) for catalysis, and it is not clear that the sensor is able to distinguish among hydrocarbon compounds in the gas stream.

The sensor to be discussed in this paper is based on dissociation of hydrocarbons in a layer of porous or of polycrystalline SiC. The use of silicon carbide allows the gas sensor to function at the high temperatures typically found in automotive exhaust streams. The sensor dissociates gases when the potential across the analyzing layer, porous or polycrystalline silicon carbide, is varied. Hydrocarbon gas molecules adsorbed on the surface or on the walls of the pores are selectively broken by varying the applied field across this layer. This sensor may be built either as a field effect transistor (FET), in which ionic buildup at the insulation layer results in a variable depletion region below the gate, or as a capacitor. Different weight hydrocarbons will dissociate at different potentials, thus making it possible to identify the hydrocarbons. Gas concentrations are determined by reading the magnitude of current flow.

A prototype sensor composed of a porous SiC layer photo electrochemically etched in an n type 6H-SiC wafer (i.e. see inset in Fig. 1) has been fabricated and tested. A chromium grid was evaporated on the porous layer to provide an equipotential contact and a path for the diffusion of gas into the sensor while a nickel contact was deposited on the unetched side of the SiC wafer. Experiments show the sensor's ability to distinguish among an inert gas, argon, and the two hydrocarbons methane and propene. Experiments in streams of the pure gases showed non-linear, reproducible differences in current-voltage curves, run from 0 - 10 V across the device. Figure 1 shows a plot of the current differences between methane and propene, normalized to the argon response, thus eliminating pure resistive effects in the current-voltage curves. Experimental evidence of the ability to distinguish among gases in mixed streams will also be presented.

REFERENCES

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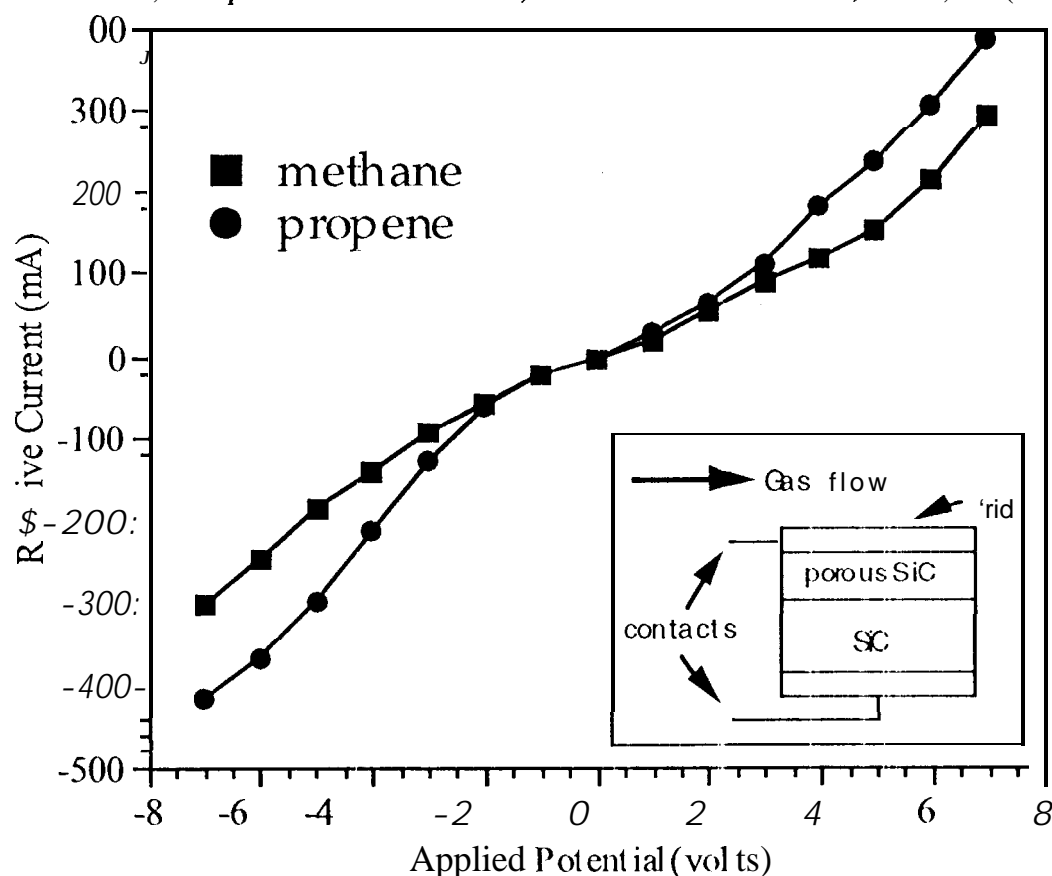


Figure 1. Current differences between methane and propene at 223°C, normalized to the argon response.